

# The Role of Spacecraft Pointing Jitter & Photon Statistics, in 3D-Reconstruction of EUVI/SECCHI Stereo Images

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## Previous analyses:

- Spacecraft pointing requirement is 3.75" (2  $\sigma$ ), i.e. 1.9" (1  $\sigma$ ) or 3.8 TRACE pixels
- The EUVI requires 0.8 " to 1.2" (3  $\sigma$ ) pointing stability for optimal performance.
- Simulations were done with perfect statistics.
- Number of observable features scaled as the 2th to 4th power of the resolution.
- Number of tie points scaled to the 3rd power of the resolution.

## Current Status:

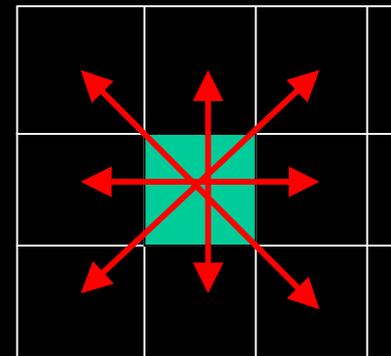
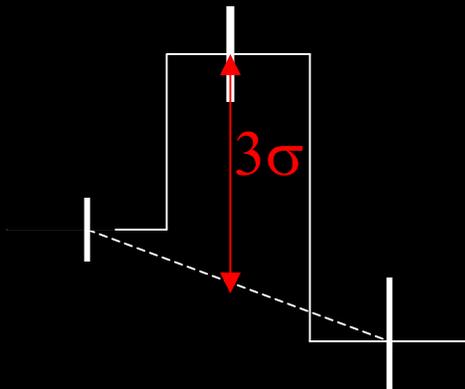
- Spacecraft pointing requirement is 3.75" (2  $\sigma$ ), i.e. 1.9" (1  $\sigma$ ) or 3.8 TRACE pixels
- The EUVI requires 0.8 " to 1.2" (3  $\sigma$ ) pointing stability for optimal performance.
- The EUVI ISS, which provided 0.1" (1  $\sigma$ ) pointing, was descope
- A lower cost Fine Pointing System (FPS) was added, which provides 0.3 to 0.6" (1  $\sigma$ ) stability
- We consider the affect of statistics on the pointing requirements.

## EUVI Fine Pointing System:

- Secondary is actuated, but strain gauges and analog electronics are eliminated.
- Open loop system limits ultimate accuracy and limits the upper limit to the frequency response
- Provides 0.8" to 1.9" p-p accuracy

## Approach :

- A measure of the quality of stereoscopic 3D reconstruction is the fraction of pixels in an image that are suitable as stereoscopic tiepoints.
- We consider pixels that have a signal-to-noise ratio of  $S/N > 3\sigma$  relative to a background given by neighbored pixels as suitable for stereoscopic tiepoints



4 neighbor directions

# Signal-to-Noise Ratio of a Pixel :

- Background based on neighbored pixels:

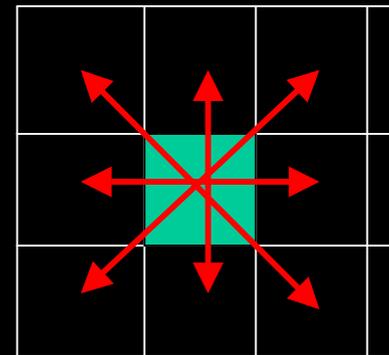
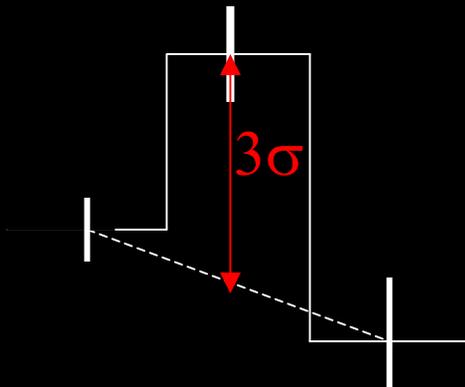
$$DN_{back} = (DN_{i+1,j} + DN_{i-1,j}) / 2$$

- Noise of background:

$$\zeta_{i,j} = \sqrt{\zeta_{photon}^2 + \zeta_{instr}^2}, \zeta_{photon} = \sqrt{DN_{back} / gain}$$

- Signal-to-Noise ratio (maximum from 4 directions):

$$S / N = DN_{i,j} / \zeta_{i,j}$$



4 neighbor directions

# Noise components:

(Example based on TRACE, 171 Å, 0.5" pixels)

(From Aschwanden, Nightingale, Tarbell & Wolfson 2000, ApJ 535, 1027)

## Instrumental noise components:

- Readout noise: 1.58 DN
- Digitization noise: 0.50 DN
- Lossless compression: 0.10 DN
- Pedestal/Dark current: 1.32 DN
- Integer subtraction: 0.70 DN

$$\sigma_{Instr} = 2.2 DN$$

## Photon statistics:

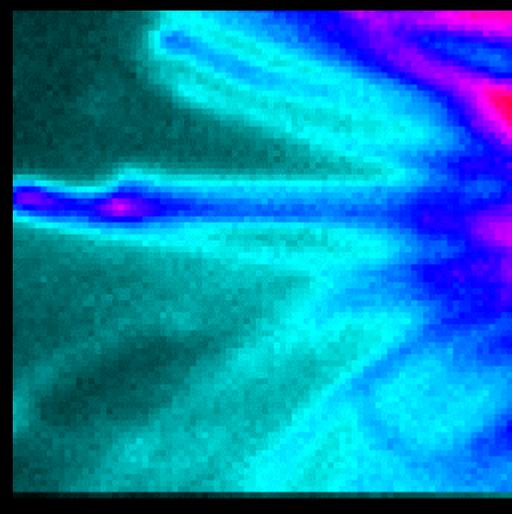
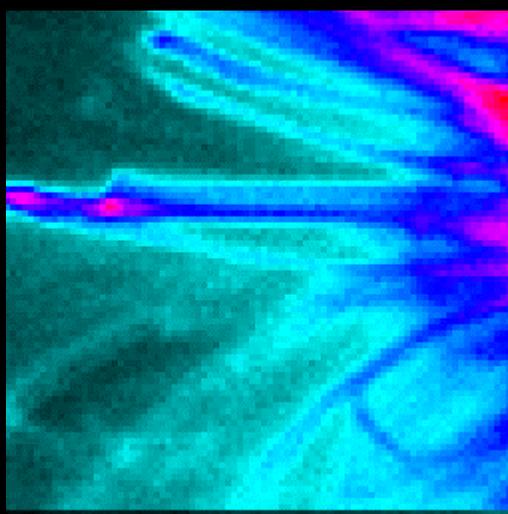
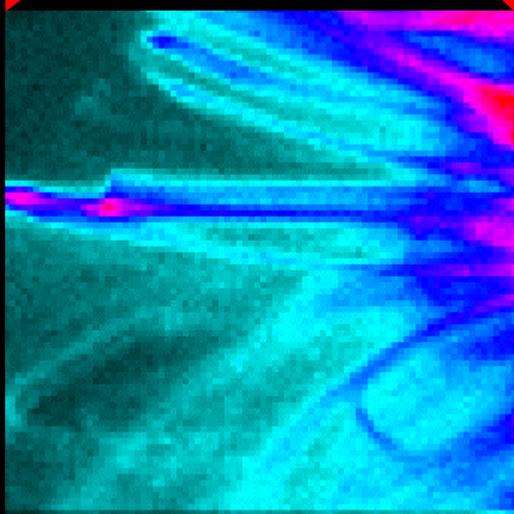
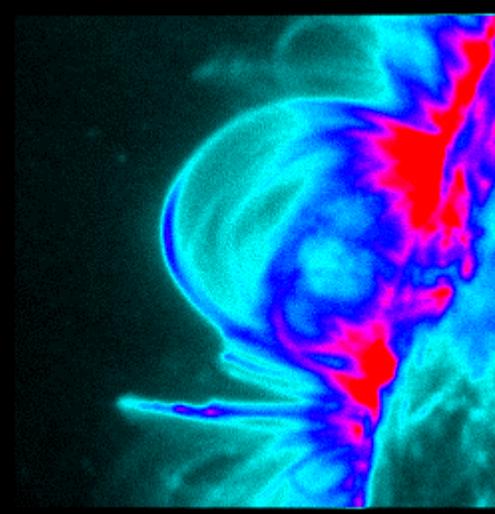
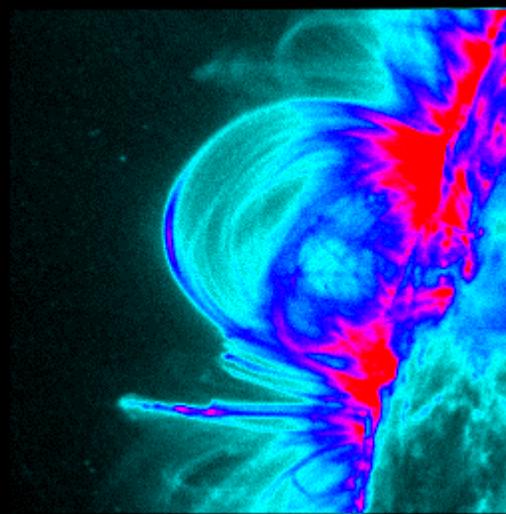
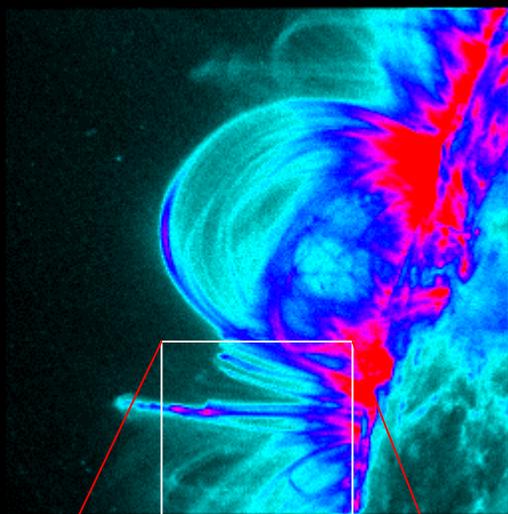
- TRACE gain: 12 electrons/DN

$$\zeta_{photon} = \sqrt{DN/12}$$

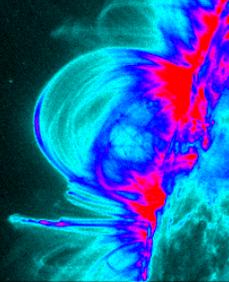
No jitter

Jitter=1.3 pixels

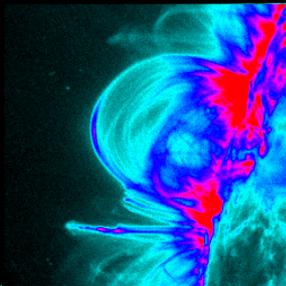
Jitter=3.8 pixels



No Jitter:

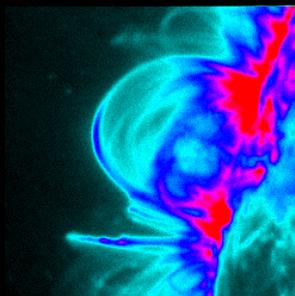


3.9% pixels with  $S/N > 3s$



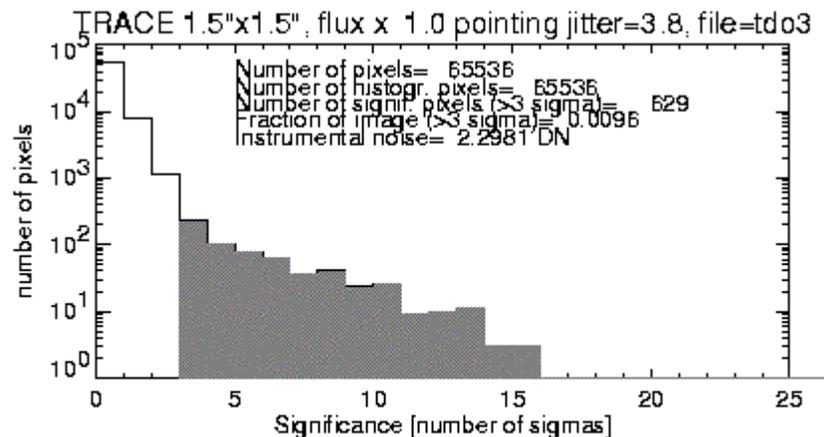
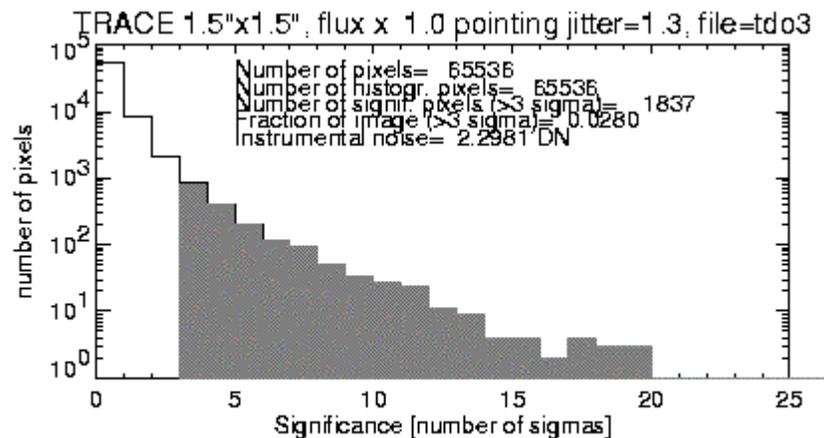
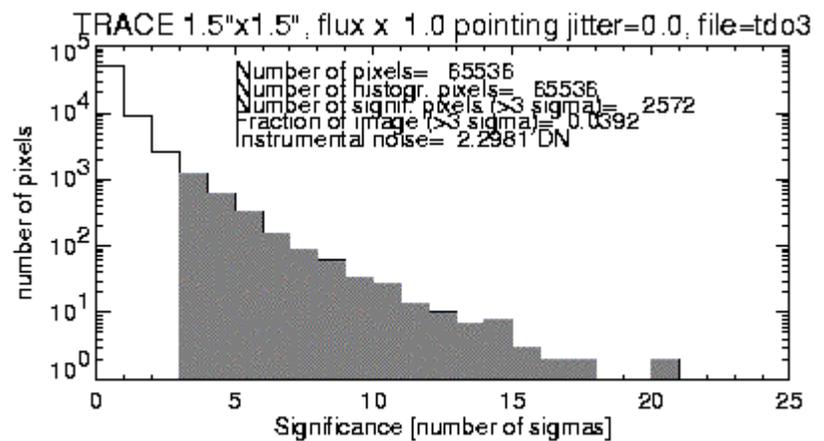
Jitter = 1.3 pixels:

2.8% pixels with  $S/N > 3s$



Jitter = 3.8 pixels:

0.96% pixels with  $S/N > 3$



# TRACE DN x 1

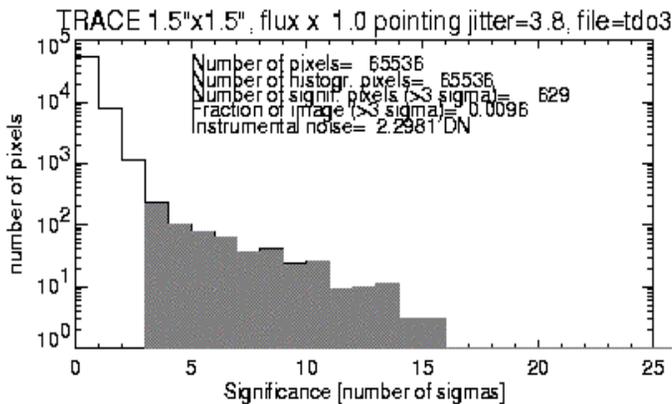
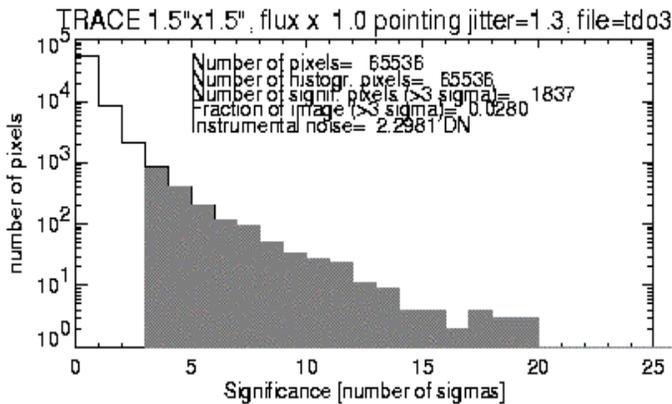
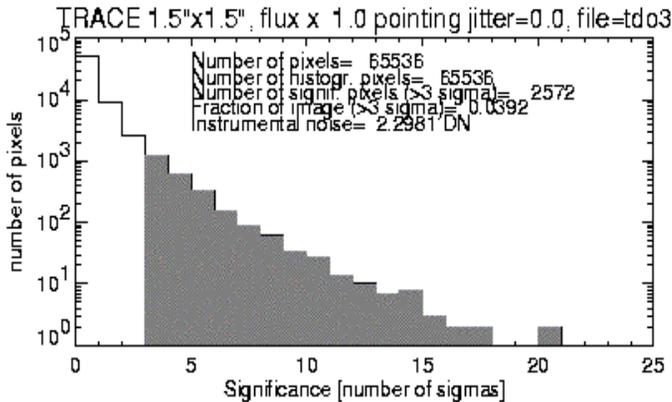


Figure 1 : Aschwanden, Wuelsel, Lemen (June 2001)

- TRACE statistics are comparable to that expected with EUVI
- For the image analyzed, the number of tie points decreased inversely with image resolution.
- For images with even statistical significance, the relationship is steeper.

3.9%

2.8%

0.96%

## Conclusions:

- The number of stereoscopic tie points is nonlinearly dependent on:
  - the spatial resolution (spacecraft jitter)
  - photon statistics
  - scales with a power of approximately -1.5 to -3.
  
- The FPS will provide adequate pointing resolution to achieve almost all EUVI observing objectives.